Software Requirements Specification (SRS)

Active Park Assist (APA 1)

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1 Introduction

Active Park Assist (APA) is a system that eliminates driver error to ensure that vehicle parking can be carried out in an accurate and safe manner. APA allows a driver to park a vehicle with minimal interaction by using sensors to detect empty parking spaces nearby and park while constantly detecting obstacles in its path. Models are included to provide more detailed interpretations, as well as a prototype that demonstrates several scenarios in which the system behaves. This document details the requirements, functionality, elements, and uses of APA that assists drivers to park their vehicles with minimal interaction.

1.1 Purpose

Put SRS in parenthesis after this ---> "Software Requirements Specification (SRS) "

The purpose of this Software Requirements Specification document is to outline the different requirements and models we are going to be using to define our system. With these models we can try to make a system that is defined and is able to work with our customers requirements. Our SRS includes a use case diagram, a domain model, a sequence diagram, state diagrams, and prototypes/scenarios. Our intended audience is the stakeholders and Dr. Cheng/Ms. Eileen.

1.2 Scope

The APA feature is designed with the intent of taking advantage of technology already available on the vehicle to automatically park their car with minimal driver interaction. This feature allows a vehicle to automatically park itself in either a parallel or perpendicular parking space. The interaction with the customer is through the HMI (Human Machine Interface) only. When engaged by the driver, the APA processes camera feed and sensor data to identify nearby empty parking spots and controls the vehicle’s powertrain, brake, and steering. The APA system calculates distance between

vehicles to determine if there is enough distance between for parking. Once a spot has been identified, the driver verifies the selection on the HMI. While the APA system is engaged, sensors detect obstacles in the path of the vehicle and respond with warnings to the driver through sound alerts on the speakers and visual alerts on the HMI. If an obstacle is detected in the path of the vehicle or the driver engages the brakes, the APA is disengaged.

1.3 Definitions, acronyms, and abbreviations

SRS - Software Requirements System
APA - Active Park Assist
HMI - Human Machine Interface

define UML here

1.4 Organization

Give more exact info about what is inside of each section. Could go for a table of contents type of structure with more detail about each section.

The remainder of the document is organized as follows. Section 2 also describes the major functionality of APA. Section 3 provides a list of enumerated requirements. Section 4 models the requirements from the previous section. Section 5 shows a rapid prototype for how the system behaves in the scenarios described in the above section. Section 6 provides credit to the resources referenced in making this system. Section 7 provides a point of contact for further information about this project.

2 Overall Description

Subsystems could be explained a bit somewhere in section 1/2 as they are mentioned later on in the document (ex: Powertrain Subsystem, Position Subsystem, etc.)

In this section we will be talking about different parts of the system. In 2.1 we will cover the product perspective which mentions how our system operates on a general scale, 2.2 the product functions and the main purpose of the system, 2.3 the user characteristics and how a user would go about using the system, 2.4 the constraints regarding the system, 2.5 some assumptions we will make about the system, and 2.6 appropriate the requirements needed for this system.

2.1 Product Perspective

Review group asked why we had cameras in the front. Determine if we need cameras at the front, and if so add a short explanation about why specifically we need them at the front and back rather than just the back.

APA is a system that minimizes driver interaction by taking over the vehicle parking process in an accurate and safe manner. The system refers to the set of cameras, sensors, software, and hardware. The APA system has access and control to subsystems of the vehicle such as the powertrain, HMI, brakes, and steering. Even though the APA system is an independent system in the vehicle, it needs to coordinate with these other subsystems. In terms of hardware constraints, sensors must be placed around the vehicle and cameras installed at the front and back of the vehicle to observe

the environment.In terms of communication, every subsystem must have software to allow for operation and communication within the APA system. Last but not least, memory. The size of the vehicle's memory limits the system size and the amount of space available for data.

2.2 Product Functions

"section seems repetitive and doesn"t add much extra value"
-look into this and compare with example documents to add more info.

The system goes through many different processes while being used. While the system is in use we see different parts of the system used. We see the vehicle initially find a parking spot. After that it decelerates or accelerates as needed while it maneuvers into the spot.

2.3 User Characteristics

The user of the system, who is the driver, is assumed to be legally authorized to operate the vehicle. The user must be alert at all times and pay attention to the warnings displayed on the HMI screen and/or the auditory warnings played over the speakers in order to take over control of the vehicle if the APA system starts to fail or is taking longer than it needs to.

2.4 Constraints

The APA system is active only when the driver verifies the request through the HMI.The APA system will only take over the driving of the vehicle after a parking spot has been verified. During the parking process, the radar/camera system will continue to monitor vehicle position to ensure that vehicle does not bump into any of the other parked vehiclesThe APA system will engage the brakes if in close proximity to another obstacle.

2.5 Assumptions and Dependencies

An assumption we have made is how it is assumed that all of the subsystems already are installed and work properly. Along with this it is assumed that the software will be up to date on the vehicle. We are also under the assumption that the driver is able to operate the vehicle under the conditions presented.

2.6 Approportioning of Requirements

Additional requirements could be added on in the future to keep up to date with the needs of the stakeholders.

3 Specific Requirements

The following section lists the specific requirements for the APA system and enumerates the specific details regarding the needs of the system.

1. The system should work for both parallel and perpendicular parking spaces.
2. The system needs an HMI where the driver must select the parking type which will initiate the system to search for spots within range of the vehicle's sensors.
    a. APA will only start when the driver has initiated and verified the maneuver after a suitable spot is identified by the system.
    b. If no suitable spot is found, the system will alert the driver and the system will deactivate.
    c. The HMI should display the camera feed when maneuvering.
    d. HMI should have a full override option from the driver.
3. The parking spot that is desired shall be clear of obstacles before the system begins the maneuver.
4. The system will use 4 wide-angle cameras placed on each side mirror, the rear hatch, and the grille on the front of the vehicle to create the birds-eye view of the vehicle.
5. Ultrasonic sensors should be mounted on the side of the vehicle to measure if spaces have the proper amount of space to fit our vehicle.
    a. The space must be greater than 1.2x the length of the vehicle.
    b. The space must have 3 feet of room on each side of the vehicle.
6. Cameras and sensors will continuously monitor surroundings of the vehicle when the system is active.
7. The cameras and sensors shall be able to identify obstacles and humans that have moved into the path of the vehicle during a parking maneuver.
    a. If an obstacle is obstructing the desired parking space during the movement, the car will stop until the obstacle is removed.
    b. If the vehicle moves within 10 inches of any obstacle that is outside of the parking space, it will stop, back up, and use the sensors to readjust.
8. The system needs access to the accelerator, steering, and brakes to automate the parking.
9. The system needs to be able to go forward and reverse.

Number 8 implies 9, add as subsection/remove (repetitive)

10. After the system parks the car, the car will be put into park and deactivate the system automatically.
11. The max speed of the vehicle during active park assist is 5 mph. As the vehicle moves within 6 feet of a neighboring vehicle, it will slow to 2 mph. Within 3 feet, it will slow to <1 mph.
12. The driver will have braking access while APA is operating.
13. An application shall be created for the cell phone which allows the driver to control speed and position while outside the vehicle and allow the driver to initiate the system.
14. To ensure security of this application, the application shall be linked to the driver's password protected account in order to only allow operation from this account.
15. If a failure is thrown from any of the car's subsystems during a parking maneuver which directly affects a functionality of the APA system, the parking maneuver should not continue and the driver should be notified of the failure via HMI.
16. The system must be able perform necessary calculations such as radius of turn and angle of steering in order to park the vehicle.
17. Cameras and sensors should be resistant to below freezing or very hot conditions.

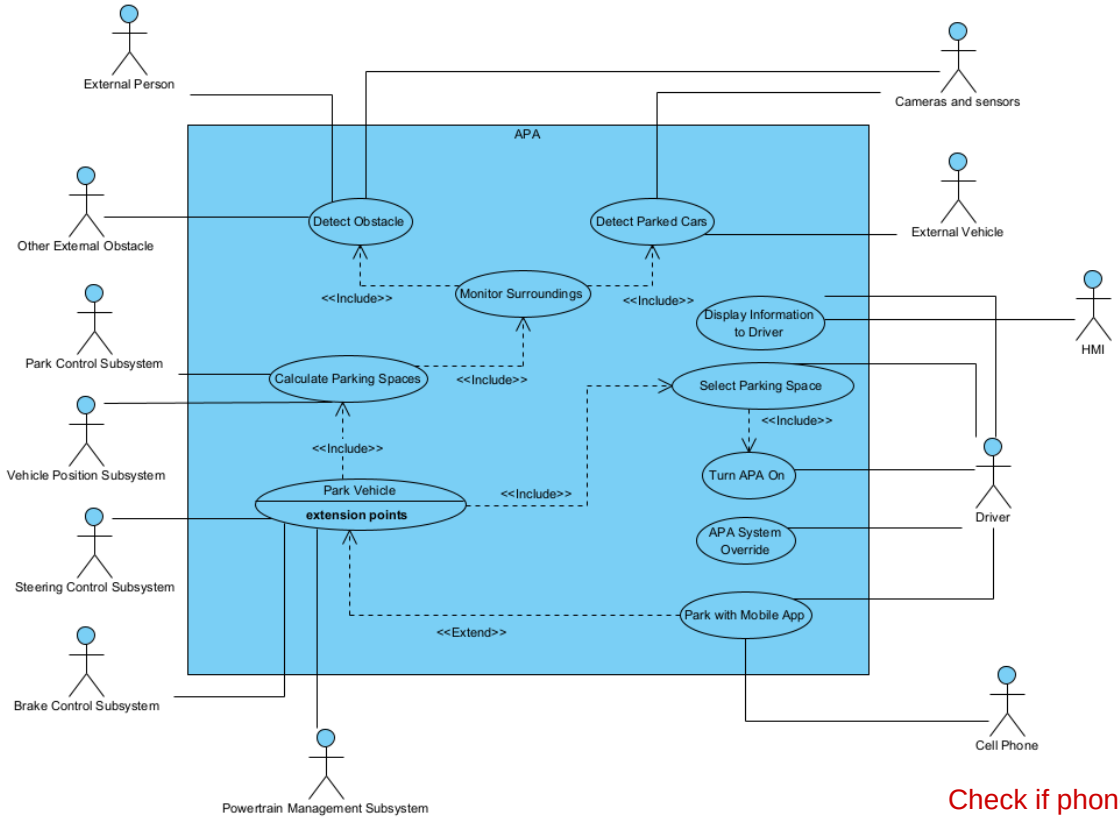
4 Modeling Requirements

The models in this section visually represent the requirements of the system and its structure. These visuals include a use case diagram, a domain model, sequence diagrams, and state diagrams to express the functionality and organization of the system.

4.1 Use Case Diagram

The following use case diagram in figure 1 is a representation of the high-level functionalities of the APA system. The system boundary is represented by the blue box, which is the APA system. The use cases are represented by the ovals within the system boundary. The actors are represented by the stick figures on the outside of the boundary. The different interactions between actors and use cases are expressed by the lines and arrows as seen in the diagram.

external person/obstacle is redundant --> make into one.
-possibly moving obstacle vs non-moving?



Should subsystems be actors?
We think yes since they are external to the APA system itself

Check if phone should be actor.
"user should be attentive while driving"
-leave cell phone as actor

Figure 1: Use Case Diagram

Table 1: The tables below detail the use cases from the above diagram showing the exact meaning of each use case and the requirements that are covered in each.

Use Case:	Detect Obstacle
Actors:	Other external obstacle, external person, cameras and sensors.
Description:	System will be able to detect obstacles and be sure that no obstacles are in the way of detected parking spots. This will be accomplished by way of 4 wide-angle cameras to allow full external coverage of the vehicle. Sensors will also be used for this detection. Obstacles that move into the way during a maneuver will be detected. This should work in abnormally hot or cold conditions.
Type:	Secondary
Includes:	N/A
Extends:	N/A
Cross-refs:	3, 4, 7, 7a, 7b, 17
Use Cases:	Monitor surroundings, calculate parking spaces, park vehicle

Use Case:	Detect Parked Cars
Actors:	External vehicle, cameras and sensors
Description:	The system should detect cars for both parallel and perpendicular parking spaces. Sensors should be able to ensure spaces have enough room for the vehicle (1.2x length of car and 3 feet of room on each side). This should work in abnormally hot or cold conditions.
Type:	Primary

Includes:	N/A
Extends:	N/A
Cross-refs:	1, 5, 5a, 5b, 17
Use Cases:	Monitor surroundings, calculate parking spaces, park vehicle

Use Case:	Monitor Surroundings
Actors:	N/A
Description:	The system should monitor the surroundings of the vehicle constantly when APA is active. This includes both the detection of obstacles and parked cars to validate parking spaces.
Type:	Primary
Includes:	Detect obstacle, detect parked cars
Extends:	N/A
Cross-refs:	6
Use Cases:	Calculate parking spaces, park vehicle

Use Case:	Calculate Parking Spaces
Actors:	Park control subsystem, vehicle position subsystem
Description:	System should be able to perform necessary calculations such as radius of turn and angle of steering to complete parking maneuver.
Type:	Secondary
Includes:	Monitor Surroundings
Extends:	N/A
Cross-refs:	16

Use Cases:	Park vehicle, select parking space

Use Case:	Park Vehicle
Actors:	Steering control subsystem, Brake control subsystem, powertrain management subsystem
Description:	System should be able to park in both parallel and perpendicular parking spaces and be able to go in reverse and forward. This requires access to the accelerator, steering, and brakes. System will deactivate and put the car in park after parking the vehicle. Max speed during APA will be 5 mph. As the vehicle moves within 6 feet of a neighboring vehicle, it will slow to 2 mph. Within 3 feet, it will slow to <1 mph.
Type:	Primary
Includes:	Calculate parking space, select parking space
Extends:	N/A
Cross-refs:	1, 8, 9, 10, 11
Use Cases:	N/A

Use Case:	Display Information to Driver
Actors:	HMI, Driver
Description:	HMI will display information to the driver. This includes parking options, ability to initiate the system, alerts on if parking spaces are found or not, and camera feed. Will display any system failures to the driver via the HMI. Information can also be displayed through the Ford App for the system.
Type:	Secondary

Includes:	N/A
Extends:	N/A
Cross-refs:	2, 2a, 2b, 2c, 2d, 13, 15
Use Cases:	N/A

Use Case:	Select Parking Space
Actors:	Driver
Description:	The driver will be able to select a parking space after a valid space is found from the system after the driver has turned on the system. The driver will also be able to select the parking space via the Ford App.
Type:	Primary
Includes:	Turn APA on
Extends:	N/A
Cross-refs:	2, 2a, 13
Use Cases:	Park vehicle

Use Case:	Turn APA On
Actors:	Driver
Description:	The driver should be able to turn on the system via the HMI and also be able to initiate the system via the HMI.
Type:	Primary
Includes:	N/A
Extends:	N/A
Cross-refs:	2, 13
Use Cases:	Select parking space, park vehicle

Use Case:	APA System Override
Actors:	Driver
Description:	The driver should have braking access during a maneuver. The driver shall also be able to completely override the system during a maneuver if they choose to.
Type:	Secondary
Includes:	N/A
Extends:	N/A
Cross-refs:	2d, 12
Use Cases:	N/A

Use Case:	Park With Mobile App
Actors:	Driver
Description:	Application will allow the driver to control speed and position from outside of the vehicle, along with the ability to initiate the system. The app should be secured by a password protected account of the driver linked to the app so that outsiders cannot easily control the system.
Type:	Secondary
Includes:	N/A
Extends:	Park Vehicle
Cross-refs:	13, 14
Use Cases:	N/A

4.2 Domain Model

capitalize figure, be consistent

The following domain model in figure 2 demonstrates the structure of the APA system in the form of a UML class diagram. The blue boxes correspond to components of our system with the lines representing different types of interactions between the system's several components. The overall goal of this model is to show how the different pieces of our system interact in order for our system to work as intended.

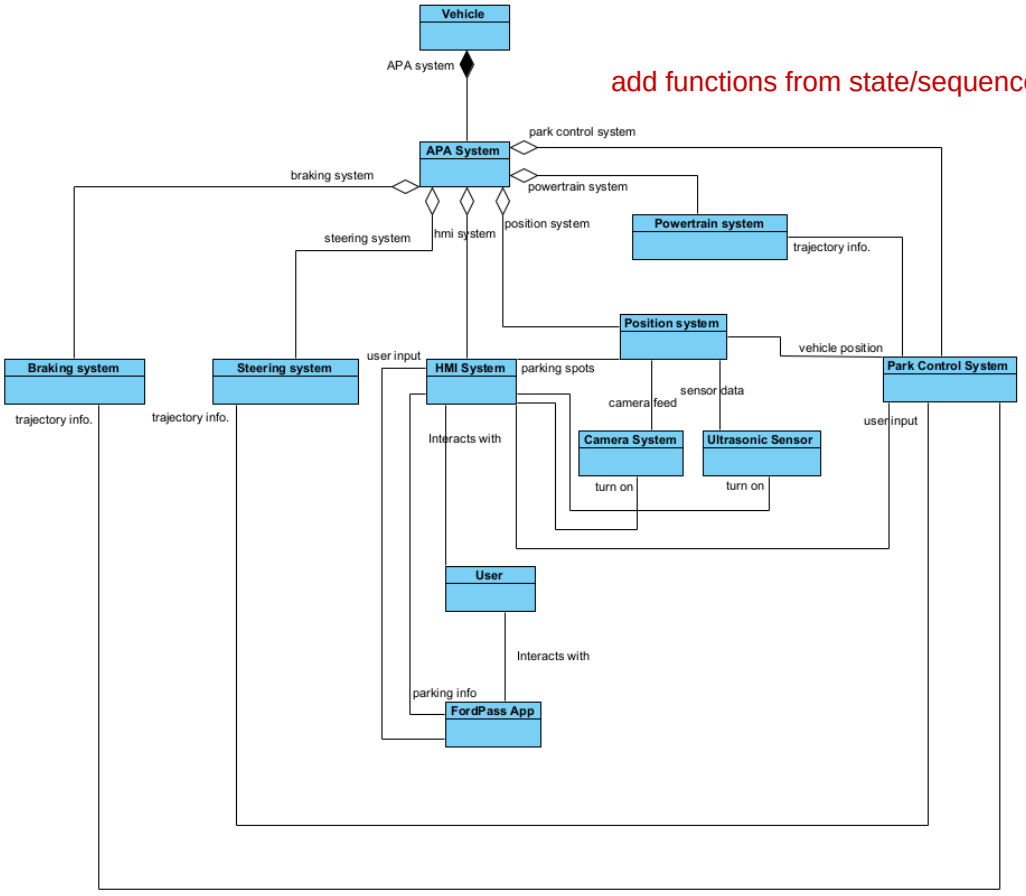


Figure 2: Domain Model

Table 2: The tables below describe the individual components of the domain model in further depth.

Name	Vehicle
Description	The vehicle that our system is inside of.
Relationships	Composition: APA System - The vehicle contains the APA

	system.
Attributes	
Operations	

Name	APA System
Description	The APA system itself.
Relationships	Composition: Vehicle - The vehicle contains to APA system itself. Aggregation: Braking System, Steering System, HMI System, Position System, Powertrain System, Park Control System - The APA system directly contains all of these subsystems, but they are also used in other systems of the car.
Attributes	
Operations	

Name	Powertrain System
Description	Accelerate the vehicle and select the gear lever position in order to meet the required trajectory.
Relationships	Aggregation: APA System - APA system contains this subsystem. Association: Park Control System - Accepts input from the park control system in order to perform its functions.
Attributes	
Operations	

Name	Braking System
Description	Brakes the vehicle in order to meet the required trajectory for parking.
Relationships	Aggregation: APA System - APA system contains this subsystem. Association: Park Control System - Accepts input from the park control system in order to perform its functions.
Attributes	
Operations	

Name	Steering System
Description	Steer the vehicle in order to meet the required trajectory for parking.
Relationships	Aggregation: APA System - APA system contains this subsystem. Association: Park Control System - Accepts input from the park control system in order to perform its functions.
Attributes	
Operations	

Name	HMI System
Description	Accepts customer inputs, displays camera information, and handles telltales / warnings.
Relationships	Aggregation: APA System - APA system contains this subsystem. Association:

	User - The user interacts with the HMI Park Control System - HMI sends user input to this system. FordPass App - Parking information is sent to the ford app along with user input from the app being sent to the HMI. Position System - HMI receives identified available parking spots. Camera System/Ultrasonic Sensors - System turns these systems on when the user starts APA.
Attributes	
Operations	

Name	Position System
Description	Processes data from the vehicle's cameras / sensors in order to identify parking spots and verify vehicle position throughout the duration of a parking event.
Relationships	Aggregation: APA System - APA system contains this subsystem. Association: HMI System - HMI receives identified available parking spots. Camera System - Camera feed is accepted to be processed in this system. Ultrasonic Sensor - Sensor data is accepted to be processed in this system. Park Control System - Position information is sent to park control system.
Attributes	
Operations	

Name	Park Control System
Description	Accepts the customer input from the HMI subsystem, calculates the vehicle trajectory based on information from the Vehicle

	Position Subsystem, and issues commands to the other subsystems.
Relationships	Aggregation: APA System - APA system contains this subsystem. Association: Powertrain System - Sends trajectory information to the powertrain system. Position System - Accepts vehicle position information from the position system. HMI System - Accepts user input information from the HMI. Steering System - Sends trajectory information to the steering system. Braking System - Sends trajectory information to the braking system.
Attributes	
Operations	

Name	Camera System
Description	Contains the cameras and feeds the camera feed to the rest of the system.
Relationships	Association: Position system - Sends camera feed to the position system. HMI System - Camera system is turned on when the user initiates APA through the HMI.
Attributes	
Operations	

Name	Ultrasonic Sensor
Description	Contains the sensors used for detecting external objects.
Relationships	Association: Position system - Sends sensor information to the position system.

	HMI System - Sensors are turned on when the user initiates APA through the HMI.
Attributes	
Operations	

Name	User
Description	The user that is interacting with the system.
Relationships	Association: HMI System - User interacts with the HMI. FordPass App - User interacts with the app to control APA.
Attributes	
Operations	

Name	Ford Pass App
Description	The app that can be used to access the APA system from outside of the vehicle.
Relationships	User - User interacts with the app to control APA. HMI System - Parking information is sent to the ford app along with user input from the app being sent to the HMI.
Attributes	
Operations	

4.3 Sequence Diagrams

The following section lists many common scenarios that may be encountered and contains a sequence diagram to visually express how our system will handle these situations. The blue boxes represent objects within our system, and the arrows represent movement through the system and the interactions between the different objects that are used for the specific scenario.

should cameras and sensors always be on? or only when APA system is on

Figure 3 below represents the system in a normal parking scenario in a perpendicular parking space where there is a car on either side of the parking space and the space is a valid size.

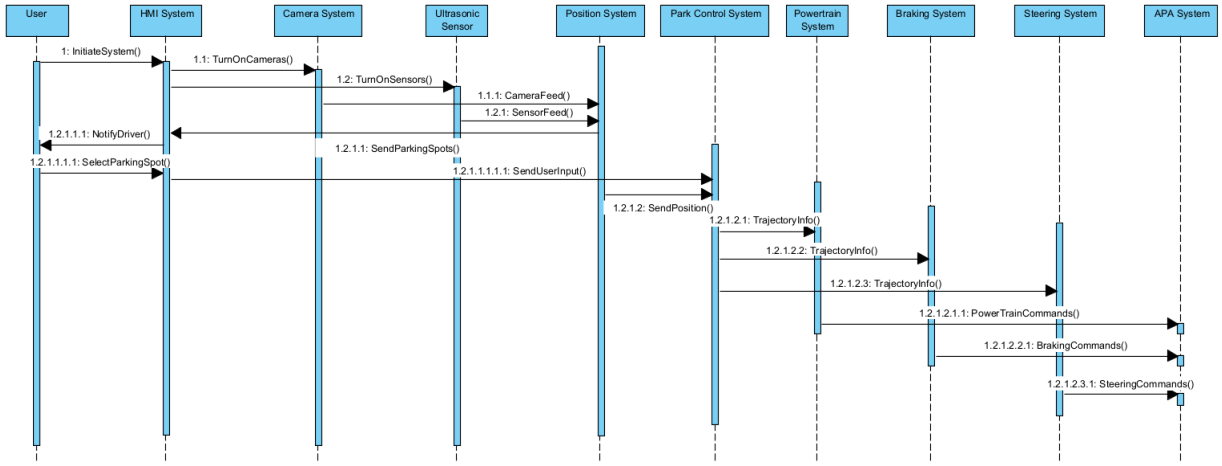


Figure 3: Sequence diagram for a normal parking scenario

Figure 4 below represents the system under normal, working conditions using the FordPass mobile app to park into a valid parallel parking space.

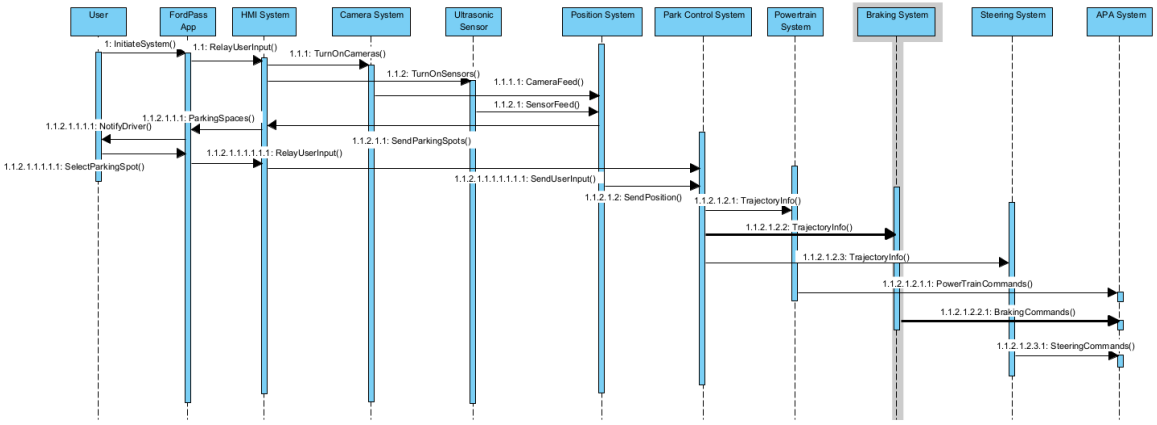


Figure 4: Sequence diagram for a normal parking scenario using FordPass app

Figure 5 below represents the system in the case that an obstacle is close to the car during a maneuver and the driver is worried and decides to perform a full override of the system during the movement in order to exit the system.

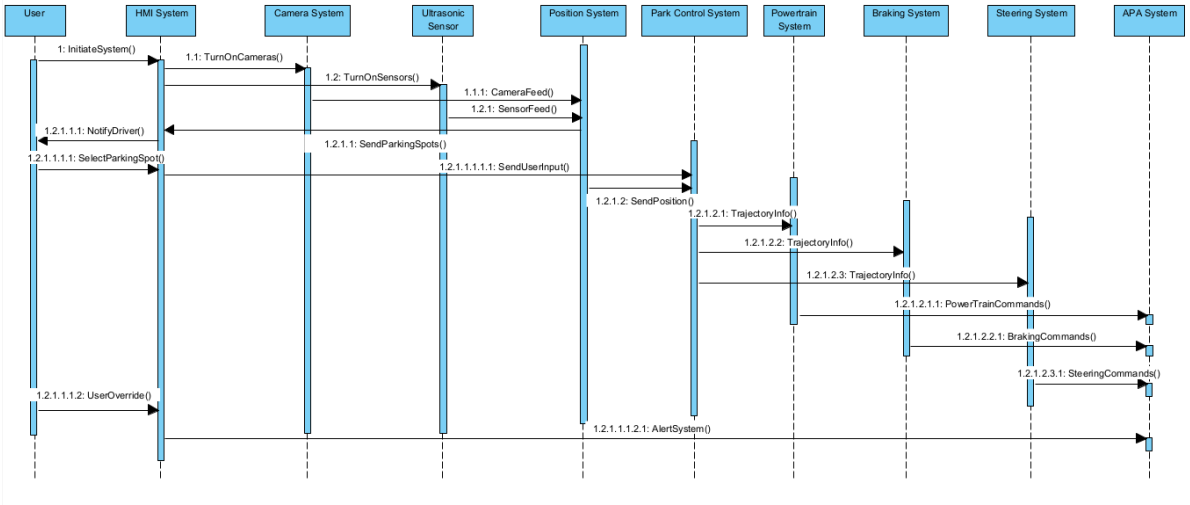


Figure 5: Sequence diagram for a scenario using driver override

Figure 6 below represents the system if there is a failure in the camera system that is detected when the driver activates the APA system via the HMI.

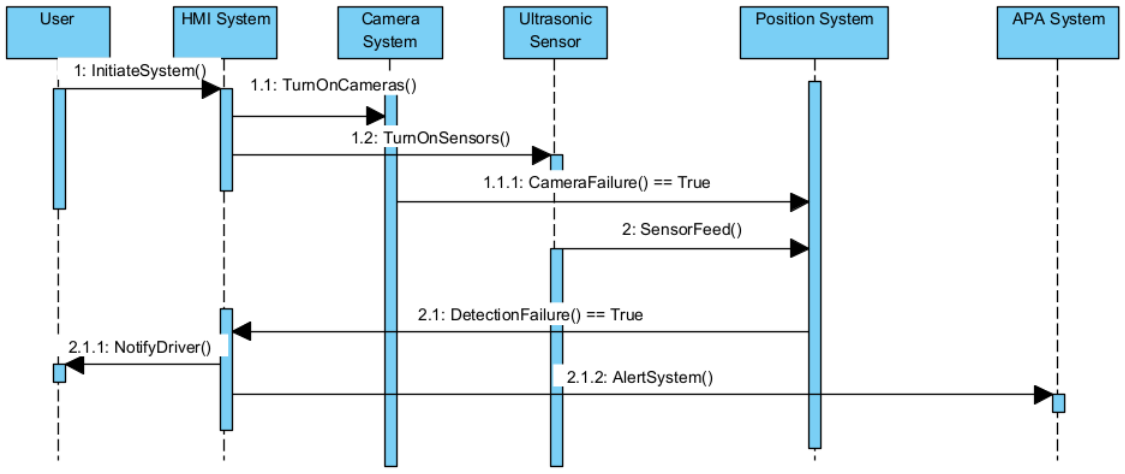


Figure 6: Sequence diagram for a scenario where there is a camera failure

Figure 7 below represents the system in the case that the sensors and cameras are unable to detect any valid parking spaces within range of the car.

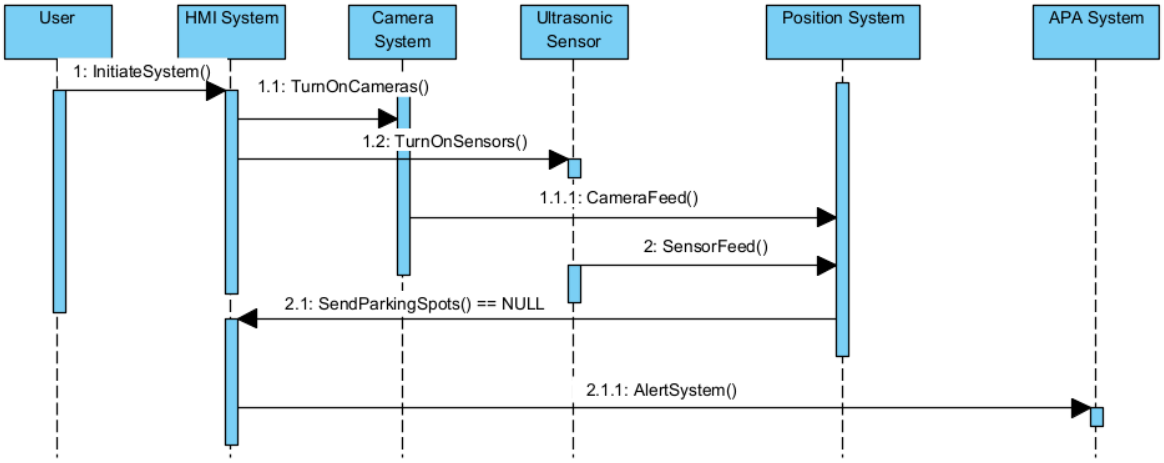


Figure 7: Sequence diagram for when there are no available parking spaces

Figure 8 below represents the system in the case that a person walks behind the vehicle during the parking maneuver, blocking the targeted parking space. The person then moves out of the way of the vehicle, clearing the parking space.

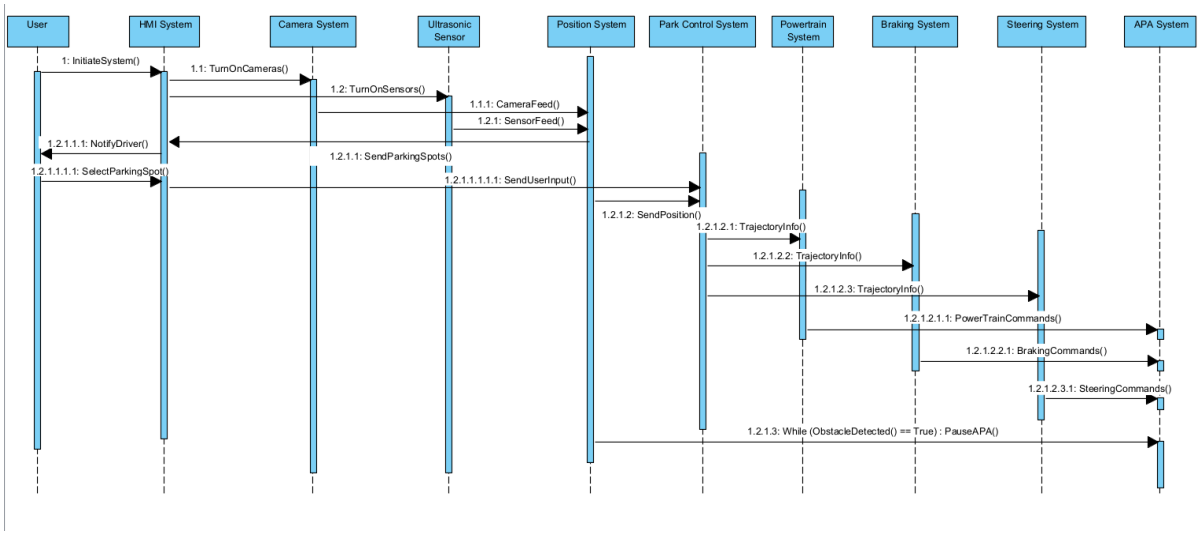


Figure 8: Sequence diagram for a person walking into the space during a maneuver

4.4 State Diagrams

The following section will contain several state diagrams for each of the main components of our system. Each state diagram will express visually how each component transitions between its states. The blue boxes represent the different states and the arrows express the transitions between the states.

The state diagram as seen in figure 9 shows the different states for the APA system as a whole. The system can either be off, on, or paused. The system will shift from off to on when the user starts the system and from on to paused if an obstacle is detected that endangers the vehicle or blocks the parking space during the maneuver. The system will transition from paused to off when any obstacles are cleared from danger. Lastly, the system will go from the on state to the off state when the maneuver is completed or the user overrides the system.

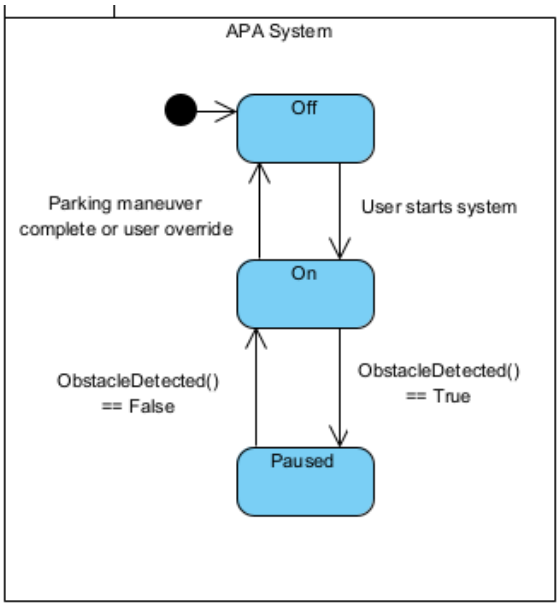


Figure 9: State diagram for the APA system

The state diagram as seen in figure 10 shows the different states for the braking system. The system will transition from the off state to the on state when brakes are applied and then back to the off state when the brakes are no longer being applied.

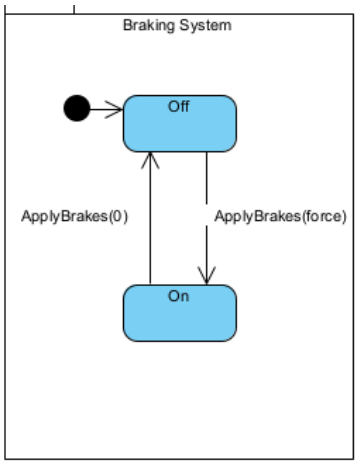


Figure 10: State diagram for the braking system

The state diagram as seen in figure 11 shows the different states for the powertrain system. The system contains four states which are park, reverse, neutral, and drive. These states are transitioned through each other as seen in the diagram when the gear of the car is switched.

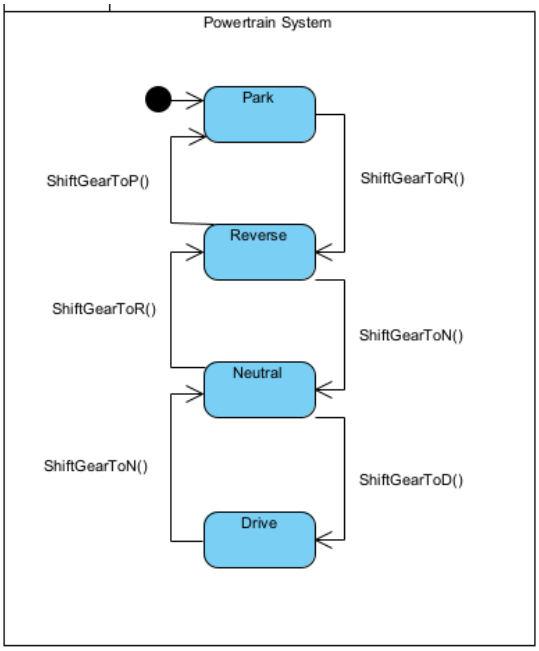


Figure 11: State diagram for the powertrain system

The state diagram as seen in figure 12 shows the different states for the steering system. The steering system begins the in off position and will move to the on position when the system is active. The wheel will either need to turn right or left based on which movement is needed during the parking maneuver. The system will return to off when APA is deactivated.

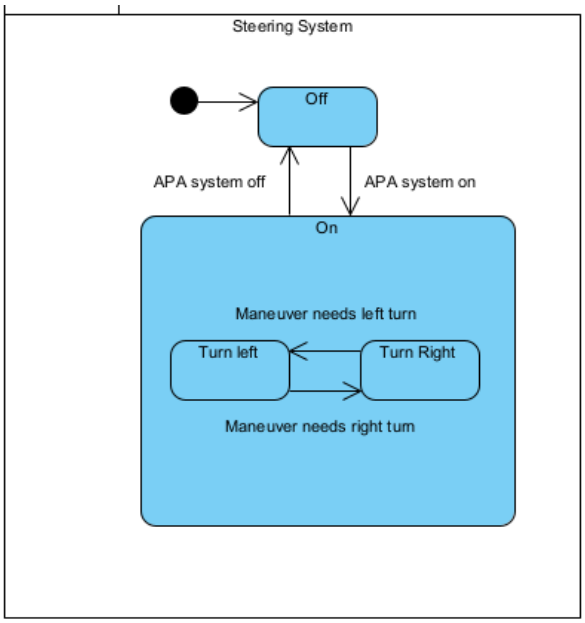


Figure 12: State diagram for the steering system

The state diagram as seen in figure 13 shows the different states for the position system. The position system begins in the off position and will turn on with the APA system. It will return off when APA has deactivated.

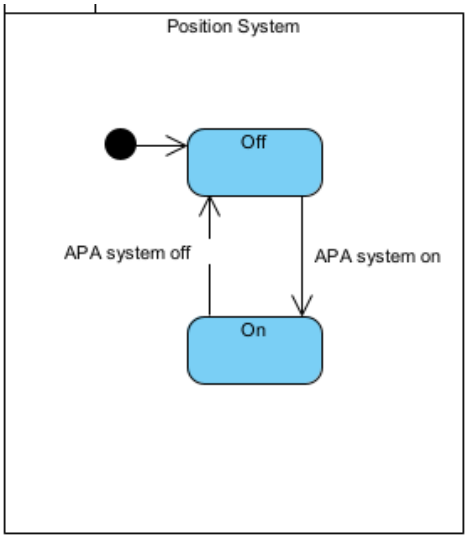


Figure 13: State diagram for the position system

The state diagram as seen in figure 14 shows the different states for the park control system. The system starts in the off position and moves on when APA is activated. When it is on, it is either calculating trajectories or issuing commands based on that information as seen in the diagram. It will move back to the off state when APA is no longer active.

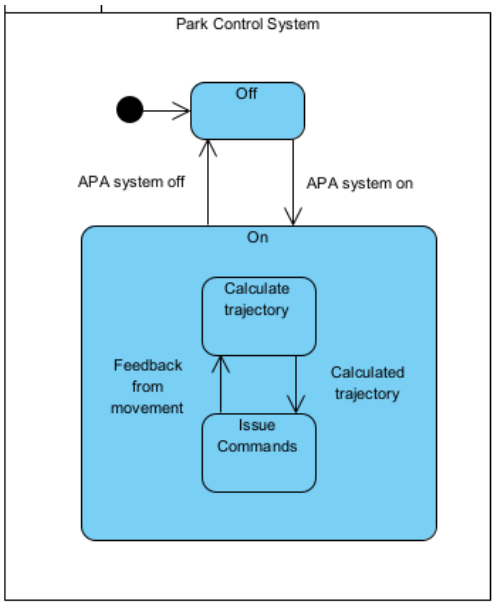


Figure 14: State diagram for the park control system

The state diagram as seen in figure 15 shows the different states for the camera system. The system starts in the off position and moves on with the APA system. It will turn off when APA is no longer active.

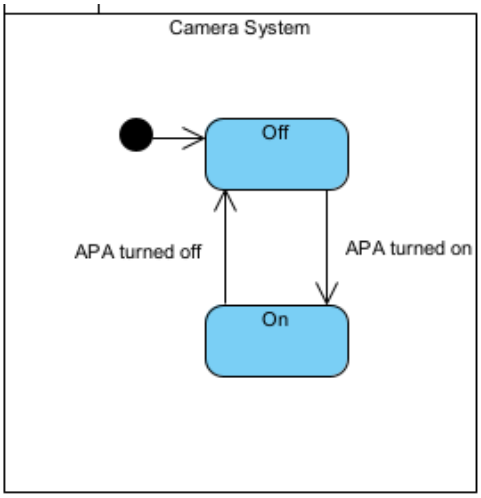


Figure 15: State diagram for the camera system

The state diagram as seen in figure 16 shows the different states for the HMI system. The system will be off until APA is activated. While the system is on, there can be warnings that may popup or pop ups where the system may need to wait on user input, as seen in the diagram. The system will turn off when APA is no longer active.

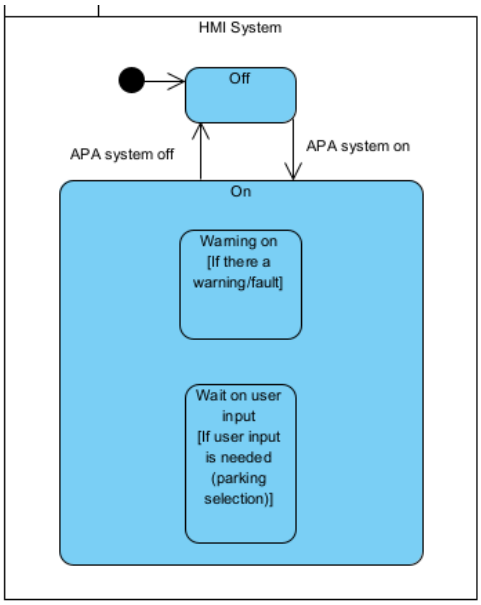


Figure 16: State diagram for HMI system

The state diagram as seen in figure 17 shows the different states for the ultrasonic sensor. The sensors are off until the APA system turns on and will turn off with the APA system.

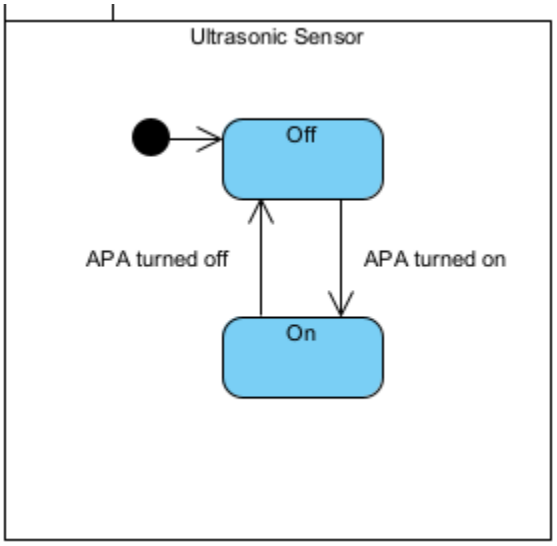


Figure 17: State diagram for the ultrasonic sensor

The state diagram as seen in figure 18 shows the different states for the Ford Pass App. The app will be off until the user enters the app and then will enter the on state. When the user exits the app, the app will return to the off state.

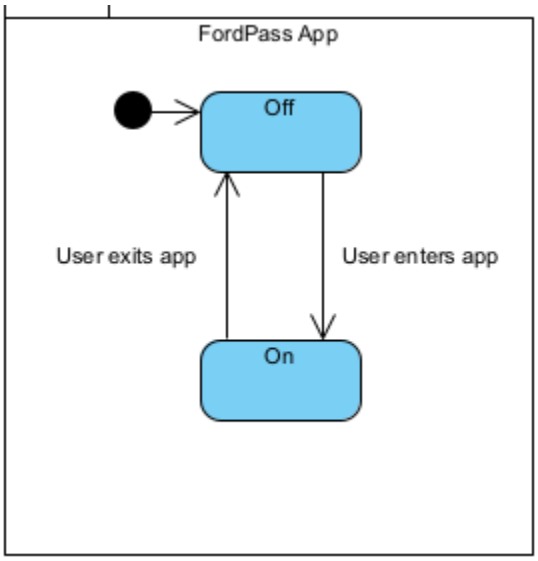


Figure 18: State diagram for the Ford Pass application

5 Prototype

in the prototype the parked cars shift to side when demonstrating movement, reviewers said it would be smoother if they didn't

5.1 How to Run Prototype

To run the prototype, navigate to our team website at https://www.cse.msu.edu/~justic35/ and click on the "Prototype" link in the navigation bar at the top. You will be given a list of scenarios to choose from. Once you click on a scenario, you will be directed to a page that has links and/or buttons to initiate the scenario. Clicking on a link or button will show you how the actors end up after the system completes the parking maneuver.

5.2 Sample Scenarios

Scenario 1:

Demonstrate a normal parking scenario in a perpendicular parking space where there is a car on either side of the parking space and the space is a valid size. The system is operated from the HMI inside the car.

In Figure 19, the scene on the left side of the arrows shows how the cars will be set up just before the parking maneuver. The car labeled “user” will be the one to perform the maneuver. The system will alert the driver of the open spot and display a button to start parking. Once the user chooses to start the maneuver, the system will direct the car to back into the space, and end as shown on the right side of the arrow.

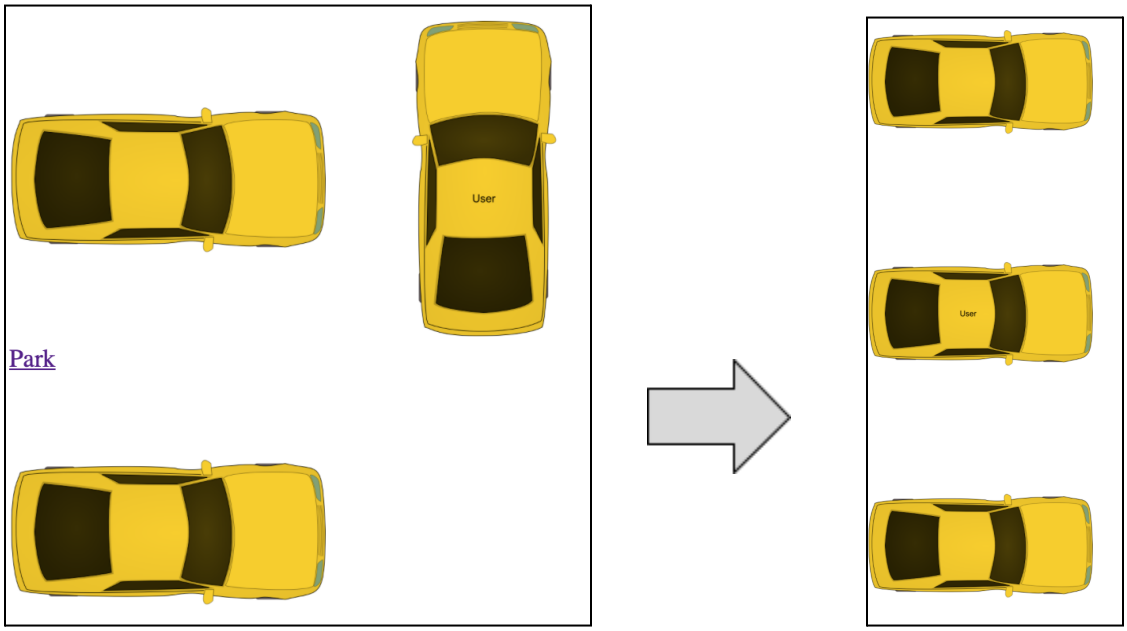
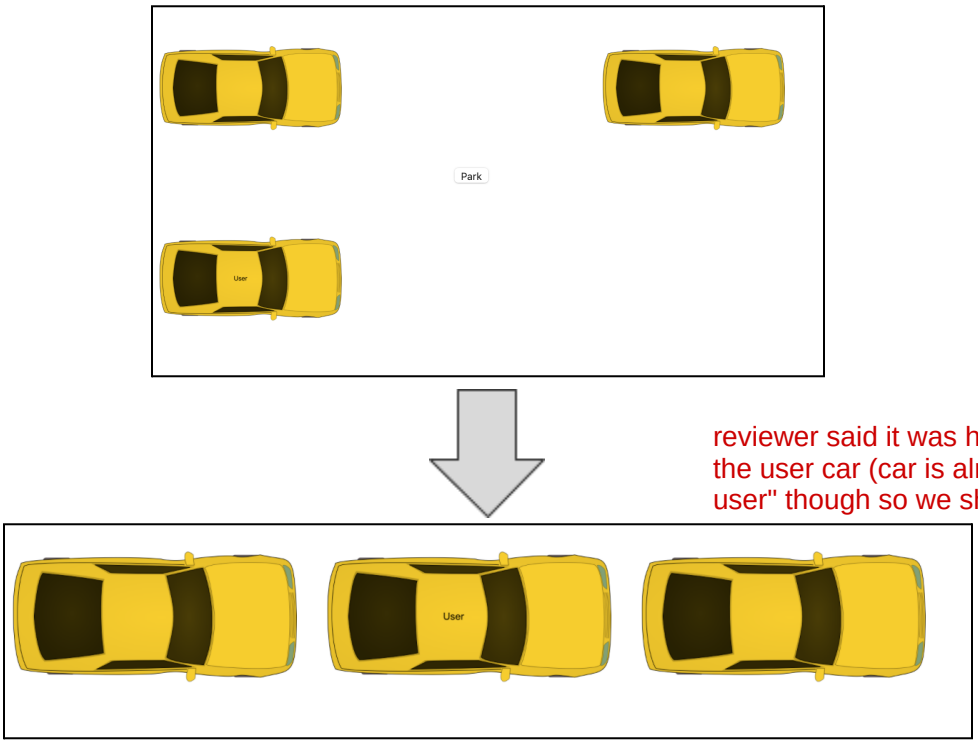


Figure 19: Parking Scenario 1

Scenario 2:

Demonstrate a normal parallel parking scenario. Assume that the length of the parking spot must be > 1.2x the length of the vehicle. The vehicle speed should be limited to < 5 mph.

In Figure 20, the scene above the arrow shows the cars before a parallel parking maneuver. After the user starts the operation, the system will direct the user car to parallel park between the two other cars. The maneuver will end with the cars in the positions seen below the arrow.



reviewer said it was hard to tell which was the user car (car is already labeled with " user" though so we should be fine here)

Figure 20: Parking Scenario 2

6 References

[1] E. Davidson, “Active Park Assist”, 2022.

[2] T. Agbebi, A. Justice, J. Kippe, S. Ravipati, A. Zeitoun, “ Active Park Assist 1 ”, *Team Page,* 2022. [Online]. Available: https://www.cse.msu.edu/~justic35/

7 Point of Contact

For further information regarding this document and project, please contact **Prof. Betty H.C. Cheng** at Michigan State University (chengb at msu.edu). All materials in this document have been sanitized for proprietary data. The students and the instructor gratefully acknowledge the participation of our industrial collaborators.